MECHANICAL FREEZER

The patent application of Edward L. Warren, U. S. A. citizen, resident of 3912 Snowy Egret Dr., Melbourne, FL 32904 USA, inventor of "Mechanical Freezer".

BACKGROUND—FIELD OF INVENTION

The present invention relates to a reciprocating, two-stroke mechanical freezer with one piston moving in with a sinusoidal motion and one or more displacer pistons moving in non-sinusoidal motion so that it obtains cooled compression.

BACKGROUND – DESCRIPTION OF PRIOR ART

The Mechanical Freezer is one of the more efficient of the practical freezer cycles, but the past mechanization of the Mechanical Freezer relied on two pistons operating with sine wave motion. An example of this is Ishiki et al (1987, U.S. Pat. No. 4,697,420). The cycle produced by this arrangement deviates from a true constant temperature compression. Another inventor has used a cam to move a secondary piston, but that was in an internal combustion engine C. H. Hutchinson (1922, U.S. Pat. No. 1,440,150).

SUMMARY

The Mechanical Freezer cycle is composed of three processes. A constant temperature compression process, an expansion process, and a constant volume heating process (heat transfer from the load). The Mechanical Freezer of this invention closely approaches that ideal cycle by using power piston **106** and displacers **104** and **105**. Power piston **106** is moved up and down by power input shaft **50**. Displacers **104** and **105** are moved up and down by cam **108**. When power piston **106** moving up and additional displacer **105** moving down come together, fluid is forced through additional heat sink **41** where it is cooled as it is compressed. When additional displacer **105** and primary displacer **104** come together, fluid is forced through primary heat sink **40** where it is cooled as it is

compressed. After compression, the cooled fluid is expanded by power piston **106** along with displacers **104** and **105** moving down. When displacers **104** and **105** then move up, fluid is forced through load **30** and load **30** is cooled.

OBJECTS AND ADVANTAGES

The advantage of the Mechanical Freezer is that it can cool the working fluid very efficiently because the cooled compression can approach constant temperature compression by using many additional compressors.

DRAWING FIGURES

FIG. 1 shows the preferred embodiment of the freezer at the end of the heating process (cooling of the load), and at the start of the additional compression process.

FIG. 2 shows the preferred embodiment of the freezer at the end of the additional compression process, and at the start of the primary compression process.

FIG. 3 shows the preferred embodiment of the freezer at the end of the primary compression process, and at the start of the expansion process.

FIG. 4 shows the preferred embodiment of the freezer at the end of the expansion process, and at the start of the heating process (cooling of the load).

FIG. 5 shows the first alternate embodiment of the freezer at the end of the heating process (cooling of the load), and at the start of the additional compression process.

FIG. 6 shows the second alternate embodiment of the freezer at the end of the heating process (cooling of the load), and at the start of the primary compression process.

FIG. 7 shows the third alternate embodiment of the freezer at the end of the heating process (cooling of the load), and at the start of the primary compression process.

FIG. 8 shows the fourth alternate embodiment of the freezer at the end of the heating process (cooling of the load), and at the start of the additional compression process.

REFERENCE NUMERALS IN DRAWINGS

heat exchanger low-pressure side	**20**
load	**30**
primary heat sink	**40**
additional heat sink	**41**
power input shaft	**50**
connecting rod	**60**
valve cams	**70**

push rods	**80**
heat exchanger high-pressure side	**90**
cylinder	**100**
cylinder head	**101**
primary displacer	**104**
additional displacer	**105**
power piston	**106**
cam	**108**
primary cam follower	**110**
additional cam follower	**111**
primary isolation valve	**112**
additional isolation valve	**113**
load isolation valve	**114**
primary inlet valve	**118**
additional inlet valve	**119**
fluid inlet port	**120**
pressurizing valve	**130**

DESCRIPTION – Figs. 1 to 4 – Preferred Embodiment

The preferred embodiment of the invention employs a two-stroke cycle divided into three processes. The first is the cooled compression process, the

second is the expansion process, and the third is the heating process (cooling of the load). The heating process (cooling of the load) is heat addition at constant volume, and is the where the load gets cold.

The cooled compression process starts at about 15% of the travel up of power piston **106** and ends with power piston **106** at about top dead center. The expansion process starts with power piston **106** at about top dead center and ends at about 85% of the downward travel of power piston **106**. The heat addition at constant volume process starts at about 85% of the downward travel of power piston **106** and ends at about 15% of the travel back up of power piston **106**. The cooled compression process can be divided into many parts. Figs 1 to 4 show it divided into two parts the additional compression and the primary compression. The additional compression part starts at starts at about 15% of the travel up of power piston **106** and ends at about 50% of the travel up of power piston **106**. The primary compression part starts at about 50% of the travel up of power piston **106** and ends with power piston **106** at about top dead center.

The above positions are all estimates and are given for descriptive purposes only. The actual position a process of the cycle may begin or end at may be different from those set out above. In addition, because primary displacer **104** does not operate sinusoidally, one process can be longer than another.

Cylinder **100** contains cylinder head **101**, power piston **106**, primary displacer **104**, and additional displacer **105**. Power piston **106** is driven with a

sinusoidal motion through connecting rod **60** by power input shaft **50**. Primary displacer **104** is driven through primary cam follower **110** by cam **108**. Additional displacer **105** is driven through additional cam follower **111** by cam **108**. The up and down motion of primary displacer **104** and additional displacer **105** is determined by the shape of the grooves in cam **108**. Load **30** transfers cold out to a load not shown. Power input shaft **50** transfers work into the freezer from a power source not shown. Pressurizing valve **130** allows the complete engine to be pressurized.

Attached to cylinder **100** are three paths. The load path contains load isolation valve **114**, load **30**, heat exchanger low-pressure side **20**,and fluid inlet port **120**. The primary path contains primary inlet valve **118**, primary heat sink **40**, heat exchanger high-pressure side **90**, and primary isolation valve **112**. The additional path contains additional inlet valve **119**, additional heat sink **41**, and additional isolation valve **113**.

Primary inlet valve **118** and primary isolation valve **112** isolate primary heat sink **40** from cylinder **100** during part of the cycle. Additional isolation valve **113** and additional inlet valve **119** isolate additional heat sink **41** from cylinder **100** during part of the cycle. Load isolation valve **114** and fluid inlet port **120** isolate load **30** from cylinder **100** during part of the cycle. Valve cam **70** and push rod **80** operate primary isolation valve **112**, additional isolation valve **113**, and load isolation valve **114** from power input shaft **50**.

The primary displacer **104**, along with primary cam follower **110**, a groove in cam **108**, primary heat sink **40**, primary isolation valve **112**, and primary inlet valve **118** make up the primary compressor. The additional displacer **105**, along with additional cam follower **111**, a groove in cam **108**, additional heat sink **41**, additional isolation valve **113**, and additional inlet valve **119** make up an additional compressor. As many of these additional compressors as desired can be added to give intercooled compression approaching constant temperature compression.

The working fluid could be air or any gas or mixture of gases. The fluid in the system can be maintained at any pressure through pressurizing valve **130**.

OPERATION – Figs. 1 to 4 – Preferred Embodiment

Figs. 1 to 4 present the sequence of steps or processes occurring in the preferred embodiment of the freezer. The additional cooled compression process takes place between Figs. 1 and 2. The primary cooled compression process takes place between Figs. 2 and 3. The expansion process takes place between Figs. 3 and 4. The heating process (cooling of the load) takes place between Figs. 4 and 1.

Fig. 1 shows: Cylinder **100** about to start the additional cooled compression process. Primary displacer **104** and additional displacer **105** are at the top of cylinder **100**. Power piston **106** is at about 15% of its upward travel. Primary isolation valve **112** is closed, Additional isolation valve **113** is closed, load

isolation valve **114** is closed, primary inlet valve **118** is closed, additional inlet valve **119** is closed, and fluid inlet port **120** is covered.

Between Fig. 1 and Fig. 2 additional cooled compression takes place. Additional isolation valve **113** opens, and when the pressure builds up between additional displacer **105** and power piston **106**, additional inlet valve **119** opens. Additional displacer **105** is moved down by cam **108** to the top of power piston **106**. As additional displacer **105** moves down and power piston **106** moves up, fluid is forced through additional heat sink **41** and is cooled as it is compressed into the space above additional displacer **105**. Additional isolation valve **113** and additional inlet valve **119** close.

Fig. 2 shows: Cylinder **100** about to start the primary cooled compression process. Primary displacer **104** is at the top of cylinder **100**, and additional displacer **105** is at the top of power piston **106**. Power piston **106** is at about 50% of its upward travel. Primary isolation valve **112** is closed, Additional isolation valve **113** is closed, load isolation valve **114** is closed, primary inlet valve **118** is closed, additional inlet valve **119** is closed, and fluid inlet port **120** is covered.

Between Fig. 2 and Fig. 3 primary cooled compression takes place. Primary isolation valve **112** opens, and when the pressure builds up between primary displacer **104** and additional displacer **105**, primary inlet valve **118** opens. Primary displacer **104** is moved down by cam **108** to the top of additional displacer **105**. As primary displacer **104** moves down and power piston **106** moves up, fluid is forced

through primary heat sink **40** and heat exchanger high-pressure side **90** and cooled as it is compressed into the space above primary displacer **104**. Primary isolation valve **112** and primary inlet valve **118** close.

Fig. 3 shows cylinder **100** about to start the expansion process. Primary displacer **104** and additional displacer **105** are at the top of power piston **106**, and power piston **106** is at about top dead center. Primary isolation valve **112** is closed, additional isolation valve **113** is closed, load isolation valve **114** is closed, primary inlet valve **118** is closed, additional inlet valve **119** is closed, and fluid inlet port **120** is covered.

Between Fig. 3 and Fig. 4 the expansion process takes place. Primary displacer **104**, additional displacer **105**, and power piston **106** move down together. Primary displacer **104** and additional displacer **105** are moved down by cam **108**, and power piston **106** is moved down by power input shaft **50**. Load isolation valve **114** opens.

Fig. 4 shows cylinder **100** about to start the heating process (cooling of the load). Primary displacer **104** and additional displacer **105** are on top of power piston **106**, and power piston **106** is at about 85% of its downward travel. Primary isolation valve **112** is closed, additional isolation valve **113** is closed, load isolation valve **114** is open, primary inlet valve **118** is closed, and fluid inlet port **120** is covered.

Between Fig. 4 and Fig. 1 the heating process (cooling of the load) takes place. Fluid inlet port **120** is uncovered. Primary displacer **104** and additional displacer **105** are moved up by cam **108** to the top of cylinder **100**. As primary displacer **104** and additional displacer **105** move up fluid is forced through load **30** and heated by heat coming from the load (cooling the load). It continues on through heat exchanger low-pressure side **20** and primary heat sink **40** back into cylinder **100**. Power piston **106** is moved down and back up to about 15% of its upward travel by power input shaft **50**.

DESCRIPTION – Fig. 5 – First Alternate Embodiment

The first alternate embodiment of the freezer is the same as the preferred embodiment without heat exchanger low-pressure side **20** and heat exchanger high-pressure side **90**.

DESCRIPTION – Fig. 6 – Second Alternate Embodiment

The second alternate embodiment of the freezer is the same as the preferred embodiment without the additional compressor. The additional compressor contains additional displacer **105**, along with additional cam follower **111**, a groove in cam **108**, additional heat sink **41**, additional isolation valve **113**, and additional inlet valve **119**.

DESCRIPTION – Fig. 7 – Third Alternate Embodiment

The third alternate embodiment of the freezer is the same as the preferred embodiment without heat exchanger low-pressure side **20**, heat exchanger high-pressure side **90**, and the additional compressor. The additional compressor contains additional displacer **105**, along with additional cam follower **111**, a groove in cam **108**, additional heat sink **41**, additional isolation valve **113**, and additional inlet valve **119**.

DESCRIPTION – Fig. 8 – Fourth Alternate Embodiment

The fourth alternate embodiment of the freezer is the same as the preferred embodiment without the portion of the path connecting heat exchanger low-pressure side **20** to fluid inlet port **120** and pressurizing valve **130**.

Conclusion

The advantage of the Mechanical Freezer is that it can cool the working fluid very efficiently.